

*KRAMER  
VTC.*  
J. Clark Salyer National Wildlife Refuge Dams  
(Lower Souris National Wildlife Refuge Dams)  
Along the Lower Souris River  
Bottineau County  
McHenry County  
North Dakota

HAER No. ND-4

HAER  
ND,  
5-KRA.V,  
1-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record  
Rocky Mountain Regional Office  
National Park Service  
U.S. Department of the Interior  
12795 W. Alameda Parkway  
Denver, Colorado 80225

HAER  
ND,  
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1-

## HISTORIC AMERICAN ENGINEERING RECORD

### J. Clark Salyer National Wildlife Refuge Dams (Lower Souris National Wildlife Refuge Dams)

HAER No. ND-4

*KRAMER VIC.*

Location: Along the Lower Souris River, Bottineau and McHenry Counties, North Dakota

Date of Construction: 1935-1936

Present Owner: U.S. Fish and Wildlife Service

Present Use: Damming Souris River

Significance: The dams represent a historical movement to preserve wildlife and wildlife habitat in the United States, which began in the mid-19th century and continues today. The refuge dams are significant for their association with the development of a national wildlife refuge system during the New Deal Era. At the time of its creation, the J. Clark Salyer Wildlife Refuge was considered the most important project in the Federal Government's program of migratory waterfowl habitat restoration. The dams also are representative examples of dams designed by the Federal Government during the New Deal Era for conservation projects.

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## INTRODUCTION

The development of the Upper and Lower Souris National Wildlife Refuges in the 1930s was part of a historical movement to conserve wildlife in the United States that began in the mid-19th century and continues today. This movement gained momentum from about the 1870s through the 1930s, and received an unprecedented boost of federal support under Franklin D. Roosevelt's New Deal. World War II and the post-war complacency of the 1950s weakened, but did not destroy, the conservation movement. In the three decades since 1960, the nation has become increasingly mindful and supportive of the need for conservation of all natural resources, including wildlife and wildlife habitat. More conservation and environmental protection organizations have formed than ever before in the nation's history. In addition, environmental issues have moved to the top of the nation's political agenda, as the public has gradually come to the realization that natural resources must be protected from the ravages of industrialism, if the human is to survive.

The national wildlife refuge system has been one means by which the United States has sought to conserve wildlife and its habitat. Over the course of the last 120 years, the Federal Government has also preserved natural resources by creating national parks, monuments, and landmarks, and by passing protective legislation. The United States created most of its great national parks (including Yellowstone, Glacier, Yosemite, Grand Canyon, Great Smoky Mountains, and Isle Royale) in the period between 1872 and 1940. During this period, the Federal Government also created 177 national wildlife refuges of various sizes. While the movement to create national parks lost momentum after 1940, the national wildlife refuge system continued to grow. Between 1941 and 1978, 190 more refuges were established, representing a total of approximately 33 million acres of land and water under federal protection. The New Deal Era's emphasis on conservation work for the unemployed, and the coincidence of a severe drought that devastated waterfowl populations, brought many additions to the national refuge system during the 1930s. One of the most important and effective of these was the reestablishment of habitat for migratory waterfowl upon the Souris River in North Dakota.

## HISTORY OF CONSERVATION IN THE UNITED STATES, 1870s-1970s

The movement to preserve wildlife and wildlife habitat in the United States began in the early 1870s. Sportsmen interested in preserving game for the hunt, and those interested in preserving nature for its own sake, led the movement to establish national parks, refuges, and forest. In the last three decades of the 19th century, these sportsmen and nature lovers made conservation a public issue for the first time in the United States. Sportsmen pushed for the regulation of hunters and for bans on certain types of unsportsman-like hunting practices that caused the slaughter of large numbers of wildlife. Nature lovers associations, such as the Audubon Society, grew out of mid-19th century Romanticism and sought to protect wildlife from commercial hunters. In the late 19th century, for example, the Audubon Society led a national crusade against the plume trade. Their campaign succeeded, and led to the passage of the Lacey Bill in 1900, which banned the killing of birds for their feathers. [1]

The sportsmen who supported conservation in the late 19th century were mostly of the elite class of American society. These wealthy sportsmen developed a group identity, beginning in the 1870s with the publication of several sports magazines, including American Sportsman, Forest and Stream, and Field and Stream. These elite sportsmen believed that hunters should have a code of conduct in hunting game and should possess "an aesthetic appreciation of the whole context of the sport that included a commitment to its perpetration." [2] During the 1870s and 1880s, sportsmen convinced state legislature to pass laws regulating the taking of wildlife by commercial and sports hunters. In fact, the first wildlife refuges in the nation were private parks,

established by elite sportsmen association to preserve habitat and wildlife for their own use, in the tradition of the large European game preserves. For example, in 1871, a group of wealthy sportsmen purchased land in the Adirondack mountains and established Blooming Grove Park. [3]

In 1887, Theodore Roosevelt, George B. Grinnell, and other prominent sportsmen founded the Boone and Crockett Club, which was the first private organization "to deal effectively with conservation issues on a national scope." The club played an important role in the creation and administration of the first national parks, forests and wildlife refuges. [4] It also successfully advocated laws prohibiting unsportsman-like practices in hunting. [5] Grinnell, the editor and owner of *Forest and Stream*, pushed for forest conservation through wise management in the magazine's editorials. He also lobbied actively for the protection of the wildlife in Yellowstone National Park (established in 1872) and opposed the construction of a railroad through the park. In 1893, Congress passed a bill protecting the wildlife in Yellowstone from hunters and provided federal enforcement of the gam laws. Grinnell's fifty-year struggle to protect the wildlife in Yellowstone, as well as his involvement in other conservation issues, had a significant influence on his friend Theodore Roosevelt. Consequently, the Roosevelt Administration created 5 national parks, 17 national monuments, and over 50 wildlife refuges. [6]

Also significant in the development of the national conservation was the establishment of the science of biology in the United States, which provided the institutional and intellectual foundations for a wildlife policy. The science of biology developed rapidly between 1900 and 1920. By the 1920s, "the internal supports for ecology and for the application of ecology to wildlife work were in place." [7] In 1884, Congress established the Office of Ornithology and Mammalogy in the Department of Agriculture. Later, this office would become the bureau of Biological Survey and, finally, the Fish and Wildlife Service. At first, the Biological Survey only conducted research on birds and mammals. However, as Congress passed laws protecting wildlife, it charged the Survey with enforcing those laws. [8] The agency's first law-enforcement responsibilities came as a result of the 1900 Lacey Act, which barred the interstate commerce of game killed in violation of state laws. In 1913, Congress passed the Weeks-McLean Act, giving the Secretary of Agriculture the authority to regulate duck and goose hunting seasons on the grounds that the migration of waterfowl across state boundaries constituted interstate commerce.

Five years later, the United States entered into a treaty with Canada to protect migratory birds. Under the Migratory Bird Treaty Act, the two countries worked together to set seasons, bag limits, and protect certain species. This treaty required the Biological Survey "to develop census techniques, chart migrations, and learn how to predict the level of waterfowl population." The 1918 treaty also created waterfowl refuges, which called for additional research by the Survey on habitat, food, and disease of migratory waterfowl. [9]

During the 1930s, a prolonged drought that led to significant soil erosion and dust storms in the West and Midwest led the nation to rethink the wisdom of indiscriminately draining wetlands for agriculture purposes. The effect of the drought on waterfowl was particularly devastating. In April 1930, Congress established a special committee on the conservation of wildlife resources in the United States. The committee held hearings, conducted studies, and sponsored legislation during the 1930s to protect the nation's wildlife, especially waterfowl. In 1935, Congress passed the Duck Stamp Act, which required every waterfowl hunter to purchase a stamp for \$1.00. The revenue from the stamps went toward the purchase, development, and maintenance of waterfowl sanctuaries. Previous to the passage of the Duck Stamp Act, President Franklin Roosevelt provided emergency funds for a waterfowl program by way of the Public Works Administration. Under FDR's administration, the Civilian Conservation Corps, the Works Progress Administration, and the

National Youth Administration all contributed to developing wildlife refuges during the 1930s. The Biological Survey administered all the newly-created refuges. [10]

During the 1930s, Congress also passed the Coordination Act, calling for close cooperation between government agencies engaged in public works and improvements to protect wildlife and their habitat. A Forest Wildlife Refuge Act permitted the President to set aside by Executive Order inviolate wildlife refuges within national forests. Federal financial aid for state wildlife projects was provided under the Pittman-Robertson Act of 1938. In 1937, Congress ratified a migratory bird treaty with Mexico. FDR called the first annual national wildlife conference in 1936 and created the first annual national wildlife restoration week in 1938. [11]

Wildlife preservation was an important part of the work on both the Civilian Conservation Corps and the Soil Conservation Service during the 1930s. Conservation-minded Secretary of the Interior Harold Ickes brought the Biological Survey (renamed the Fish and Wildlife Service in 1940) into the Department of the Interior. The CCC and the SCS provided professional opportunities for scientists trained in wildlife biology. They put into practice theories of game management, the creation and preservation of habitat on agricultural lands and elsewhere, and agricultural conservation. [12]

World War II curtailed the expansion of the New Deal conservation program, but the notion of preserving wildlife and their habitat survived the war and grew stronger in subsequent decades. Since the 1950s, the American public has become increasingly concerned with environmental issues, of which conservation is a part. In the early 1960s, public pressure for endangered species protection led the Fish and Wildlife Service to take more active measures in preserving certain species of wildlife. In 1964, the Service established an Office of Endangered Species and embarked on new policies to protect those species. The 1960s also brought the creation of new and more radical conservation groups who did not work in conjunction with the Fish and Wildlife Service, as older groups, such as the Sierra Club, had. During the 1960s and early 1970s, in response to pressure from conservationists, Congress passed a series of endangered species acts, as well as the Marine Mammal Protection Act. The 1964 Land and Water Conservation Act allowed the Secretary of the Interior to purchase land for the preservation of wildlife. The 1966 Endangered Species Preservation Act provided for the purchase and management of lands to protect native wildlife threatened with extinction and required the departments of Defense, the Interior, and Agriculture to protect wildlife on their lands. This legislation was strengthened by the 1969 Endangered Species Conservation Act. [13]

The passage of federal environmental legislation in the early 1970s also had a dramatic impact on federal conservation policy. The National Environmental Policy Act (NEPA, 1970), the establishment of the Environmental Protection Agency (1970), and of the President's Council on Environmental Quality (1970), were all significant. Section 10 of the NEPA required all federal agencies to prepare environmental impact statements before undertaking any major project. [14]

Environmental and conservation groups have proliferated in the United States since the 1960s, as public concern for the preservation of natural resources has grown. In 1990, environmental issues are at the forefront of the nation's political agenda and promise to remain important in future decades.

## DEVELOPMENT OF THE NATIONAL WILDLIFE REFUGE SYSTEM AND THE PROTECTION OF MIGRATORY BIRDS

A refuge program to protect the nation's wildlife resources was initiated by President Theodore Roosevelt on March 14, 1903, when he issued an executive order mandating the Federal Government to establish and administer a sanctuary for the brown pelican on Pelican Island off the east coast of Florida. Soon afterwards, in 1905, Congress established the Wichita Mountains Wildlife Refuge for the protection of the American buffalo. The government made another notable addition to the refuge system in 1908, when it developed the Klamath Lake Reservation as the first migratory waterfowl nesting reserve. [15]

Further measures to protect the nation's migratory bird populations came in the following decade. The Migratory Bird Act of 1913 established federal control over the hunting season for migratory birds. Congress strengthened this act in 1918 by passing the Migratory Bird Treaty Act, which provided for the protection of birds migrating between Canada and the United States. Under this act, both countries agreed to protect migratory birds and jointly adopted such measures as outlawing spring shoots, limiting hunting seasons to 3-1/2 months, establishing uniform bag limits, prohibiting the sale of migratory birds, and removing several endangered species from game bird status. [16] Prior to these treaties, the Bureau of Biological Survey had functioned primarily as a research institution in mind. The Migratory Birds Act of 1913 and of 1918 strengthened the Biological Survey's powers to protect wildlife and helped to establish the Bureau as a major force in the future development of a national wildlife protection system. [17]

Despite the protective action taken in the previous two decades, by the 1920s, migratory bird populations (waterfowl, in particular) continued to decline and numerous species verged on extinction. This was largely due to the agricultural boom of the early 20th century, when farmers drained millions of acres of wetlands, mostly in the plains and western states, destroying more valuable waterfowl habitat. In the mid-1920s, the Director of the Biological Survey warned that "the danger to the perpetuation of the stock of wildfowl is so great and so imminent...that there is the most vital need for all conservationists and lovers of wildlife to sink petty differences of opinion as to the details and to unite in constructive work to insure the future of our migratory gamebirds." [18] In response to this and other pleas from wildlife conservationists, Congress passed two separate acts that established the Upper Mississippi Wildlife and Fish Refuge in 1924 and the Bear River Migratory Bird Refuge in 1929. Also in 1929, Congress passed the Migratory Bird Conservation Act, which authorized spending nearly \$8 million for the purchase or lease of refuge for waterfowl. Unfortunately, with the advent of the Great Depression, most of these funds were never appropriated, greatly curtailing this effort. [19]

Not until the beginning of Franklin D. Roosevelt's administration, in the early 1930s, and implementation of his New Deal reforms, did the nation provide the organization, funding, and manpower necessary to develop a refuge system adequate to protect its wildlife resources. By this time, the nation not only faced the worst economic depression in its history, but was also suffering a severe drought. Particularly hard hit by the dust bowl conditions were waterfowl, as much of their remaining wetlands habitat had dried up. Depletion of their numbers was so great that one biologist feared "the winged millions" would never "reestablish themselves in all their early abundance." [20]

Roosevelt took action on the waterfowl crisis in early 1934. He appointed a special presidential committee, consisting of Thomas Beck, Jay N. "Ding" Darling, and Aldo Leopold, to investigate means to restore the dwindling wildlife populations. Recommendations made by this "Duck Committee" called for more funding

and restoration of nesting habitat. Darling became Chief of the Bureau of Biological Survey, and he immediately initiated an effort to develop a national wildlife refuge program. [21]

Surprisingly, Darling is not a trained biologist, but rather a political cartoonist. Natural resource conservation, however, was a recurrent theme in his work, which was published in hundreds of newspapers across the country. Through his graphic depictions of the misuse and exploitation of soil, plant, and wildlife resources, Darling gained national prominence as a conservationist and won two Pulitzer Prizes. Darling also did much to influence the conservation movement in his native Iowa. He helped organize the Iowa Division of the Isaak Walton League of America, was a leading member of the nonpartisan Iowa Conservation Commission, and was instrumental in organizing the Iowa Cooperative Research Unit, which was the first such group in the nation. [22]

Darling's first acts as the new Chief of the Biological Survey were to secure additional funding for migratory bird refuge development, reorganize the bureau by adding new divisions, and hire new personnel. Within a matter of months, Darling had funneled \$8.5 million to the refuge program, primarily from funds earmarked for a variety of emergency relief program. He also helped push through Congress the Migratory Bird Hunting Stamp Act, which taxed duck hunters to create a fund to purchase refuge lands. One of the first new branches Darling established within the Biological Survey was the Division of Wildlife Refuges. To head this new unit, Darling selected J. Clark Salyer, II, a young biologist with whom Darling had previously been associated in conservation projects in Iowa. [23]

#### **BACKGROUND TO THE DEVELOPMENT OF THE SOURIS RIVER WILDLIFE REFUGE SYSTEM**

In his new position, Salyer was delegated the tremendous task of building the nation's new refuge system. After careful review of previous studies of waterfowl migration, nesting, and feeding habits, Salyer decided to first rehabilitate and restore lost waterfowl habitat, including breeding sites, within the northwest region of the Mississippi Valley, or Central Flyway -- one of the our great bird migration routes of the North American continent. This region included some of the choicest, most productive breeding grounds in the country and included locations in North and South Dakota, Nebraska, Montana, and Minnesota. To administer and coordinate these activities, the Biological Survey in 1934 established a regional office in Minot, South Dakota, under the direction of Bernie Maurek. [24] Of all the project areas considered in the region, the area believed to offer the most outstanding opportunity for re-establishing waterfowl populations was the Souris River Valley in north-central North Dakota.

From its source in the Mouse Mountains in Saskatchewan, Canada, the Souris River winds south into Renville County, North Dakota. From there, the river meanders southeast into western Ward County, where it begins a wide bend to the east, before gradually turning north through McHenry and Bottineau counties and back into Canada. Altogether, the Souris flows 358 miles through North Dakota, but drops only 215 feet, less than one foot per mile. [26] Consequently, in its natural state, the Souris maintained thousands of acres of marshes that were revitalized by the river's floodwaters each spring. In turn, these marshes provided prime feeding, nesting, and breeding grounds for migratory waterfowl. Early explorers and settlers in the Souris River Valley reported sightings of vast concentrations of birds, including geese, swans, and cranes, as well as numerous species of ducks. One such account related that "in distant flight their masses often resembled huge clouds of smoke." [27]

The early 20th century agricultural boom in North Dakota destroyed much of this natural bird habitat. In 1912, farmers in the area, eager for additional croplands, funded a project to dredge some 30 miles of the

Souris River in Bottineau and McHenry counties to drain nearly 20,000 acres of its marshes. The costs of the project was high for the time, nearly \$10.00 for every acre affected. [28] Much of the drained marshland, however, was soon found unsuitable for the production of cash crops, such as wheat, and the project ultimately proved a dismal failure for most of the farmers involved. Landowners subsequently allowed most of the drained lands to return to native grasses used for hay. Unlike the marshes of the previous years, however, the native grasses only thrived in years of heavy spring run-off, when the Souris overflowed its banks and slowly inundated the valley. In relatively dry years, of which there were many, the grasses failed to thrive, causing both a meager hay crop and the loss of valuable waterfowl habitat. The long-term effect of the drainage project on the area's waterfowl populations proved disastrous. In 1924, E. T. Jude, the North Dakota Game and Fish Commissioner, commented on the situation by saying "...where ducks formerly bred in thousands, we find tens or none." [29]

The Biological Survey's plan to restore the Souris River marshes called for developments along two separate stretches of the river. The largest, most extensive, and varied habitat area to be improved was ultimately to be a 58,700-acre refuge situated along the downstream reaches of the river in McHenry and Bottineau counties, and called the Lower Souris National Wildlife Refuge. About 220 river miles upstream, but only 45 miles west in Ward and Renville counties, a site was selected for the smaller, 32,000-acre Upper Souris Wildlife Refuge. In 1967, the Lower Souris Refuge was renamed the J. Clark Salyer National Wildlife Refuge, in honor of J. Clark Salyer, II.

Creation of suitable wetland conditions at each of the refuges was to be achieved by construction of a network of low dams, as well as other water diversion structures, including dikes, levees accompanied by spillways, control works, and channels. Wetlands established by this network of structures would consist of ponds, marshes, and wet meadows. Water developments within the Upper Souris refuge would also include creation of a large storage reservoir. To be christened Lake Darling, in recognition of Jay "Ding" Darling, this reservoir would serve to regulate and sustain water supplies to habitat developments downstream in both refuges. The formation of Lake Darling was also intended for flood control and to provide communities in the area, in particular the city of Minot, located about 27 miles downstream from the proposed damsite, with a continuous source of fresh water. The U.S. Department of Agriculture's Bureau of Agricultural Engineering designed the system and prepared construction plans for all Souris River dams and other diversion structures.

The Lower Souris project held a key position in the Biological Survey's nationwide program to restore migratory waterfowl reproductive habitat. Of the 27 new refuges being established in the mid-1930s under the National Migratory Waterfowl Program, the Lower Souris offered "the greatest goose and duck production potentialities per acre of any project we have been able to locate up to the present time." J. D. LeCron, Assistant to the Secretary of Agriculture in 1935, called the Lower Souris Wildlife Refuge "the most important one in the whole program of migratory waterfowl restoration." [30]

Besides the creation of wetland conditions, restoration work in the refuges also required reinstatement of wildlife foods and shelter, as well as reclamation of the refuge grounds. For the manpower necessary to carry out these enormous tasks, the Biological Survey primarily drew upon the Civilian Conservation Corps (CCC). The CCC was one of several New Deal relief programs enacted by the Roosevelt Administration in 1933 and was designed to provide emergency work relief to young men between the ages of 18 to 25. CCC activities mostly involved reclamation and conservation projects on public lands. Both the Department of the Interior and the Department of Agriculture were responsible for creating work projects for the CCC and providing the personnel to manage them, while the Department of the Army had to authority to establish and maintain the camps where the CCC enrollees were to reside. For his efforts, each CCC enrollee received \$30 a month in wages, of which \$25 was sent back home to his family. [31]



At the peak of CCC operations in North Dakota, there were 16 camps. [32] Of these, at least five were engaged in wildlife refuge developments under the Biological Survey, including Camp BF-1 (Camp Maurek) on the Upper Souris project and Camp BF-4 (Camp Ding) on the Lower Souris project. CCC forces from Camp BF-5 also conducted reclamation work at the Upper Souris refuge, primarily along the northern reaches of Lake Darling. Camp BF-5 was located outside the refuge, in the town of Mohall.

#### CONSTRUCTION OF THE LOWER SOURIS WILDLIFE REFUGE DAMS

Although there were little or no apparent opposition to the Upper Souris Wildlife Refuge, the Biological Survey did encounter some local resistance to the Lower Souris project. Objections mostly concerned the "wholesale" loss of the valley's haylands and were voiced primarily by those with a vested interest in irrigation schemes that were also being suggested for the Souris River. [33] While the Biological Survey was attempting to secure the necessary lands and water rights for the Lower Souris refuge, the McHenry County Flood Irrigation Board had submitted requests for the Public Works Administration (PWA) funds for two irrigation projects to draw on the Souris River, "for the purpose of flooding our meadows in the spring and making it possible for us to produce a maximum uniform crop of hay from year to year." [34] Known as the Westford and Eaton projects, the two irrigation schemes were proposed for much of the same lands as the refuge and depended upon the same water rights. In response to protests against the refuge project, the Biological Survey agreed to revise its plans to accommodate the Eaton project, with some concessions, but insisted that the Westford project be completely abandoned. [35] With these adjustments, the refuge developments along the Souris River were hailed as the first such flood control and wild fowl marsh problems has been accomplished." [36]

#### DAMS 320, 326, 332, 341, AND 357

As originally conceived, the Lower Souris refuge was to extend along 63 river miles, with its northern boundary lying about 12 miles south of the Canadian line. Within this area would be four major dams which, from south to north, were designated as dam numbers 320, 326, 332, and 341. Except for variances in overall length and height above the river bed, all four structures had a nearly identical design: an earthfill embankment, gated outlet works, and a 700-foot-long stone masonry spillway weir. By late February 1935, the government had acquired enough lands to proceed with the project and called for competitive bids for all necessary dam work, such as "spillway riprapping, excavation, and the placing of reinforced steel." [37] By the following summer, a contract for construction of the dams had been let for \$148,318 to the Megarry Brothers of Bismarck. Manager of the firm, James Hill, had formerly served as an engineer with the North Dakota State Highway Department. [38] In less than a year, the Megarry Brothers completed all four of the dams and, on April 18, 1936, the Biological Survey closed the control gates for Dam 341 and began flooding the Lower Souris marshes. [39]

Meanwhile the government decided to extend the boundary of the Lower Souris refuge north to the Canada-United States line and, within this area, erect an additional dam. Plans for this structure, Dam 357, were completed in June 1936, and were essentially the same as the other refuge dams. [40] The CCC Company 766, which had reported for work in July 1935, provided the labor for its construction. Since January 1936, Company 766 had been building two stone masonry "plugs" or embankments at the south end of the refuge. CCC crew, working in three shifts, started construction of Dam 357 in August 1936, with hopes that the project would be finished before the onset of winter. Hampered by land acquisition difficulties and nearly 80 round-trip-miles of travel between the CCC camp and the dam site, workers did not complete the dam until the following fall. [41]

## **GENERAL PHYSICAL DESCRIPTION OF EARTHFILL DAMS BUILT AT WILDLIFE REFUGES IN NORTH DAKOTA DURING THE NEW DEAL ERA**

There are three basic components to a typical earthfill dam: the earth embankment, a spillway, and outlet works. Important features of the earth embankment are the foundation, cutoffs, the core, upstream and downstream shells, and facing materials. Homogeneous embankments consist entirely of impervious core materials, without shells. Zoned embankments have an impervious core adjoined by one or more shells. Because the upstream shell of an earthen dam becomes saturated when the reservoir is full, it should be comprised of material which drains freely when the reservoir is drawn down and of a coarse grain to avoid liquefaction during an earthquake. Because the downstream shell should never be saturated, most any material may be used which can withstand normal erosion due to weather. In most circumstances, it is not essential that the core or shells of an earthfill dam rest on impervious foundation materials, so only topsoil and other unsuitable materials are stripped prior to placement of the embankment. Where excavation of the overburden is impractical, interlocking steel sheet piling may be used for cutoff walls.

Whether homogeneous or zoned, earthen embankments have both upstream and downstream facings to protect the earthfill from erosion caused by weather and the reservoir. The upstream face of an earthfill dam must be able to resist the wave action of the reservoir. Usually, rockfall is used for the upstream face; concrete or asphalt has been successfully used in cases where rock is not readily available, but can be prone to the same problem of cracking due to differential settlement of the embankment. The downstream face may be any material which is sufficient to restore erosion of the weather, such as rock fill, or topsoil and grass.

A spillway is essential for an earth fill dam to prevent overtopping and erosion of the earth embankment, which could cause failure of the dam. A spillway must be designed to carry a maximum flood safely. A spillway is generally one of three types: 1) a chute in a channel, cut through the abutment or set in a saddle elsewhere along the rim of the reservoir; 2) a concrete gravity dam, set at some point along the length of the earth embankment; or 3) a tunnel or conduit. At its head, a spillway also has a control structure consisting of a weir, an ogee overflow (meaning that, in section, it has an S-shape), a side-channel structure, or an operable gate.

The outlet works of an earthen dam allow operators to control the volume of water discharged into the river channel below the dam for use downstream. The outlet works generally consist of an intake structure equipped with screens to keep large objects from passing through the outlet; a conduit which carries the water around, beneath, or through the dam; and gates or valves used for controlling the volume of discharge. Most spillways and outlet works also require a stilling basin designed to dissipate the energy embodied in the discharge without allowing damaging erosion to the steam channel below the dam.

## **CONCLUSION**

From the inception of national wildlife refuge system, the Souris River marshes were a key component in the preservation, propagation, and protection of waterfowl. Restoration of wetlands conditions at the two Souris River refuges had an almost immediate and dramatic effect on waterfowl populations. Between 1937 and 1939, the number of ducks frequenting the Upper Souris refuge alone reportedly increased over 150%. [42] By 1957, over 250 different bird species had been recorded on or near the refuges, including 25 species considered rare. [43] Today, the two refuges provide protection to well over 100,000 birds during their spring and fall migrations. [44]

#### FOOTNOTES

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- 3 Ibid., p. 57.
- 4 Ibid., p. 23.
- 5 Ibid., p. 121.
- 6 Ibid., p. 51.
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- 8 Ibid., p. 36.
- 9 Ibid., p. 38.
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- 11 Ibid., pp. 9-26.
- 12 Dunlap, pp. 80-85.
- 13 Ibid., pp. 122-146.
- 14 Ibid., p. 134.
- 15 Ira N. Gabrielson, "The National Wildlife Refuge Program of the Fish and Wildlife Service," in The Annual Report of the Board of Regents of the Smithsonian Institution, 1940, Washington, D.C.: U.S. Government Printing Office, 1941, p. 314; Henry M. Reeves, "FWS Operating Branches," in Flyways: Pioneering Waterfowl Management I North America, Arthur S. Hawkins, et al, eds., Washington, D.C.: U. S. Government Printing Office, 1984, pp. 346-347; Memorandum for the International Joint Commission on the International Aspects of the Relation of Souris (Mouse) River Water Supply to the Conservation of Migratory Waterfowl, June 4, 1940, pp. 1-4., Entry Supply to the Conservation of Migratory Waterfowl (folder 2a), Records Group 2-248-Upper Souris National Wildlife Refuge, National Archives, Washington, D.C. (hereafter this collection will be referred to as RG 22, National Archives).
- 16 Memorandum for the International Joint Commission, pp. 1-3, Entry 248, RG 22, National Archives.
- 17 Edward E. Hill, comp., "Preliminary Inventory of the Records of the Fish and Wildlife Service," (Record Group 22), June 1965, pp. 2-3, on file at the National Archives, Washington, D.C.

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- 22 DuMont and Reeves, "The Darling-Salyer Team," in Flyways, pp. 107-108; Peter Matthiessen, Wildlife in America, New York: The Viking Press, 1959, p. 220.
- 23 Reeves, "FWS Operating Branches," in Flyways, pp. 353-354.
- 24 Minot Daily News, August 17, 1935, p. 1.
- 25 Gabrielson, "The National Wildlife Refuge Program," p. 313; Memorandum for the International Joint Commission, p. 12, Entry 248, RG 22, National Archives.
- 26 Mouse River Farmers Press, May 23, 1935, p. 1.
- 27 Early accounts of Souris River marsh bird populations are cited from unidentified source material in the Upham Diamond Jubilee: 1905-1980, Rita Bethke and Marcia Giese, eds., Upham, ND: Upham Commercial Club, 1980, p. 106.
- 28 Minot Daily News, June 25, 1935, p. 2; Memorandum for the International Joint Commission, p. 13, Entry 248, RG 22, National Archives.
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